Original Article

Perioperative renal calculus factors affecting percutaneous nephrolithotomy outcomes

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Abstract

Objective: Percutaneous nephrolithotomy has recently become the standard procedure for large kidney calculi. The aim of this study was to analyze the overall perioperative determinants of renal calculi that affect the results of percutaneous nephrolithotomy.

Material and Method: In a single tertiary hospital in Bangkok, Thailand, Ramathibodi Hospital, we performed a retrospective analysis of patients who underwent percutaneous nephrolithotomy from 2011 to 2018. The character of the kidney stones was determined using computed tomography. A statistical analysis was performed to determine the associations between kidney stone factors and stone-free status after surgery: operative time (OT), estimated blood loss (EBL), renal function, hospital stay, and postoperative complications.

Result: The comprehensive stone-free rate was 54.8%. Stone burden presented a statistically significant stone-free rate ($p<0.05$). Only stone burden showed a correlation with postoperative blood loss and hospital stay.

Conclusion: Stone burden of renal calculiis a crucial parameter for the prediction of stone-free status.

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Introduction

Kidney calculus is a very common urologic disease that significantly impairs the quality of life of the patient because of the pain it causes and its high recurrence rate[1]. In the United States, the prevalence of urolithiasis rose from 3.2% in the period between 1976 and 1980 to 8.8% between 2007and 2010[2]. Comparable tendencies have been observed in other parts of the world[3]. Renal calculi are associated with serious urological complications[4]. Early diagnosis and management are essential to prevent irreversible damage to the urinary tract.

Up-to-date systematic reviews and meta-analyses confirm that percutaneous nephrolithotomy (PCNL) is suitable for patients with a high stone burden[5]. It is the procedure of choice for all renal calculi with a size of more than 2 cm, as well as for lower pole kidney stones between 1 and 2 cm in diameter[6]. Multiple factors may affect the success rate of PCNL, such as stone size, location, and tract length. In 2011, Thomas et al.[7] developed the Guy's Stone Score (GSS), a nephrolithometric scoring system (NSS) that classifies patients according to the complexity of their calculi and their pelvicalyceal anatomy based on plain radiography, ultrasonography, computed tomography (CT), and intravenous urography findings. The GSS is a widely accepted tool for the evaluation of renal calculi before performing percutaneous nephrolithotomy. The primary and secondary objectives of this study are to determine kidney stone factors that affect free rate status after PCNL and to evaluate the correlation with post operative outcomes.

Material and Method

Patient Population

Ethical approval for the study was obtained from the Institutional Review Board of the Faculty of Medicine, Ramathibodi Hospital, Bangkok, Thailand. We retrospectively analyzed the data from patients undergoing percutaneous nephrolithotomy in Ramathibodi Hospital between 2011 and 2018. Inclusion criteria were patients who had a complete or partial staghorn stone, underwent percutaneous nephrolithotomy, and whose CT scans were assessed using a nephrolithotomy scoring system. The study exclusion criteria were: below 18 years of age, deficient preoperative CT imaging, and patients with insufficient clinical data. The character of renal calculi affecting PCNL outcomes was retrospectively recorded by urological, surgical, and radiological staff, using the aforementioned criteria. We evaluated the correlation between each renal calculus parameter to operative results, that is, stone-free status, operative time (OT), estimated blood loss (EBL), percentage change in the estimated glomerular filtration rate (eGFR), hospital stay, and postoperative complications. Complications were determined using the Clavien-Dindo classification. Stone-free is defined as the absence of residual stones or asymptomatic, non-infectious and non-obstructive residual stone fragments with a diameter $\leq$4 mm after undergoing PCNL (clinically insignificant residual fragments).

Statistical Analysis

The character of the kidney stones and the patient demographics were analyzed using descriptive statistics. The statistical analysis was performed using the Statistical Package for the Social Sciences (version 11.5 for Windows; SPSS Inc., Chicago, IL, USA). Continuous variables were investigated using the Student's t-test. For each stone parameter, Spearman correlations were measured with the following variables: percentage change in the eGFR, operative time (OT), estimated blood loss (EBL), occurrence of complications, and hospital stay. After univariate analysis, variables with a p-value of less than 0.05 were selected for multivariate analysis.

Result

From 2011 to 2018, 204 patients with renal calculi underwent percutaneous nephrolithotomy. A

total of 146 patients (57 males and 89 females) met the analysis inclusion criteria. A total of 58 patients were excluded due to inadequate imaging studies and clinical data. The mean age of the patients was 57.6 years old. The main symptoms were flank pain in 68 patients (46.6%), macroscopic hematuria in 10 patients (6.8%), recurrent urinary tract infections in 7 patients (4.8%), and incidental findings from routine health check-ups in 61 patients (41.8%).

Patient characteristics are summarized in Table 1, and the anatomical factors of the kidney stones are shown in Table 2. The stone sizes ranged from 32 to 1672 mm^2, and the average stone size was 517 mm^2. Stone size was less than 100 mm^2 in 18 cases (62.3%), 100-400 mm^2 in 6 cases (21.4%), and over 400 mm^2 in 4 cases (16.3%). A total of 13 (8.9%) intraoperative complications occurred, including intraoperative bleeding (>500 ml);[2] patients decided to terminate the procedure. Major postoperative complications were observed in 4 cases (2.7%), including septicemia (n=2) and pseudoaneurysm, treated with embolization (n=2). The mean for GSS was 2.8. There were no conversions to open operations. Intraoperative and postoperative data are shown in Table 3.

Table 1. Characteristics of the patients underwent percutaneous nephrolithotomy (n=146).

Characteristic	No. (%) or mean (range)
Sex	
Male	57 (39%)
Female	89 (61%)
Age (years)	57.6 (18-80)
BMI (kg/m^2)	25.6 (15.8-40.3)
Chief complaint	
Flank pain	68 (46.6%)
Incidental findings	61 (41.8%)
Hematuria	10 (6.8%)
Urinary tract infection	7 (4.8%)
Smoking	19 (13%)
Preoperative eGFR (mg/dL)	75.3 (6.1-123)
Postoperative eGFR (mg/dL)	75.5 (4.7-126)
Preoperative Hb (mg/dL)	12.7 (8.5-16.4)
Postoperative Hb (mg/dL)	11.7 (7.9-15.6)
ASA classification	
class 1	139
class 2	7
Year of surgery	
2011	3 (2.0%)
2012	14 (9.6%)
2013	27 (18.6%)
2014	15 (10.2%)
2015	17 (11.6%)
2016	12 (8.2%)
2017	20 (13.8%)
2018	38 (26%)

Table 2. Anatomical factors of kidney calculi.

Characteristic	No. (%) or mean (range)
Number of stone	
1	66
2	36
3	25
More than 3	19
Side	
Right	60 (41.1%)
Left	86 (58.9%)
Size	
<100 mm^2	4 (2.7%)
100-400 mm^2	52 (35.6%)
>400 mm^2	90 (61.7%)
Length from stone to skin	86.2 (47-145)
Stone density	956.3 (280-1668)
Stone number	2 (1-8)
Guy's Stone Score	2.8 (1-4)

Table 3. Treatment outcomes.

Variables	No. (%) or mean (range)
Stone free status 80 (54.8%)	
Estimate blood loss (mL)	328 (10-2000)
Intraoperative complications	
Blood loss >500 mL	13 (8.9%)
Postoperative complications	
Fever (Clavien-Dindo grade 1)	26 (17.8%)
Blood transfusion (Clavien-Dindo grade 2)	19 (13%)
Pseudoaneurysm (Clavien-Dindo grade 3A)	4 (2.7%)
Sepsis (Clavien-Dindo grade 4B)	4 (2.7%)
Blood transfusion (No. of patients)	12 (8.2%)
Operative time (min)	150 min (50-800 min)
Hospital stay (day)	8 (4-43 day)
Duration of nephrostomy (day)	4.5 (0-17)

The correlation of renal stone parameters and stone-free status is presented in Table 4. The burden of renal calculi and stone density were significantly correlated with stone-free status. Subsequently, multivariate analysis revealed that total stone size was the most important predictor for developing stone-free status (OR 1.007, p<0.001). However, stone density was not statistically significant (OR 1.000, p=76), as seen in Table 5. The associations between stone factors and clinical outcomes are shown in Table 6. Only stone burden showed a correlation with post operative blood loss and hospital stay. Additionally, GSS also demonstrated a relationship with EBL and hospital stay.

Discussion

At present, the standard treatment of large renal calculi is surgical, and percutaneous nephrolithotomy is the preferred procedure[6]. In this study, we evaluated the character of renal calculi in patients who underwent PCNL. The advantages of percutaneous nephrolithotomy are less kidney damage compared with anatrophic nephrolithotomy and better preservation of renal function[5]. Shockwave lithotripsy has emerged as a potential alternative to PCNL for unfit or elderly patients.

PCNL alone for staghorn stones has a stone-free rate range from 49%[8] to 78%[9]. In our study, the stone-free status after percutaneous nephrolithotomy was 54.8%. Al-Kohlany et al.[8] reported a lower stone-free rate because they only studied and handled complete staghorn stones, whereas this study included all types of kidney calculi. The stone-free rate found in this study is similar to that reported by El-Nahas et al. (56.6%)[10], who incorporated subject criteria comparable to ours, especially the complete and partial staghorn stones.

We found that the stone burden PCNL parameters significantly correlated with stone-free status (p<0.05). These results are similar to the studies of Karalar et al.[11] and Atmoko et al.[12]

Several studies[13-15] have described greater stone burden as a risk factor for requiring multiple tracts and longer operative times, or resulting in inadequate stone clearance and complications. This is supported by this study's findings of more cases of blood loss and longer hospital stay. On the contrary, stone density, the number of calculi, and the distance between the skin and the calculi were not significantly related to the clinical results, as shown in Table 5.

Table 4. Association between stone factor with stone free status.

Stone factor	Mean (standard deviation)		P-value
	Stone free (N=80)	Stone not free (N=66)	
Stone burden	369.43	902.96	<0.01
Skin to stone distance	89.5	95.7	0.17
Stone number	1.40	1.40	0.94
Stone density	934.18	950.30	0.02

Table 5. Multivariate analysis.

Stone factor	Odd ratio	95% CI	P-value
Stone burden	1.007	1.004-1.009	<0.001
Stone density	1.000	0.998-1.001	0.760

Multiple studies have described significant predictors of the stone-free rate after PCNL, with stone size, number, location, and pyelocaliceal system anatomy as the suggested predictors[16,17]. Some authors have created various scoring systems in order to standardize the terminology related to stone complexity. For example, the Guy's Stone Score (GSS) was developed by Thomas et al.[7] to assess the anatomical complexity of renal calculi. This nephrolithometric scoring system (NSS) can be used to anticipate the perioperative outcomes of PCNL. Khalil et al.[18], who calculated the GSS in 100 patients undergoing PCNL, found that it has a positive association with the stone-free rate, retreatment rate, need for additional procedures, and the complication rate. Similarly, Lojanapiwat et al.[19] showed that the GSS calculated from IVP can predict the success rate and complications following an upper pole puncture of percutaneous nephrolithotomy.

Our research has multiple limitations. First, it is retrospective in nature and thus there could be some bias in the management strategies. Second limitation: the lack of a metabolic assessment in many patients, as stone analysis and metabolic tests were not used routinely for all patients. Finally, this study had a high proportion of excluded patients. Further large-scale prospective studies are needed to confirm our results.

Conclusion

The stone burden and density of renal calculi are useful parameters for the prediction of stone-free status. Our study shows the promising correlation between stone burden and perioperative outcomes of the percutaneous nephrolithotomy.

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Conflict of interest

The authors declare no conflict of interest.

Table 6. Correlations between stone factor and perioperative outcomes.

Stone factor	Stone burden		Stone to skin distance		Stone number		Stone density		Guy's stone score	
	Rho	p	Rho	p	Rho	p	Rho	p	Rho	p
% Change in eGFR	0.08	0.32	-0.08	0.32	0.06	0.47	-0.11	0.18	0.08	0.31
Operative time	0.09	0.26	-0.13	0.10	-0.01	0.99	-0.02	0.82	0.15	0.07
Estimated blood loss	0.22	0.01	-0.09	0.28	0.09	0.30	-0.19	0.82	0.2	0.01
Postoperative complications	0.05	0.55	-0.10	0.23	0.05	0.52	0.04	0.60	0.04	0.67
Hospital stay	0.20	0.02	0.03	0.70	-0.03	0.69	-0.09	0.29	0.16	0.04

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